Wilson Bull., 108(1), 1996, pp. 137–150

FOOD AVAILABILITY AND FEEDING PREFERENCES OF BREEDING FULVOUS WHISTLING-DUCKS IN LOUISIANA RICEFIELDS

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ABSTRACT.—Expansion of the breeding distribution of the Fulvous whistling-duck (*Dendrocygna bicolor*) into the southeastern United States after the mid-1800s coincided with the establishment of rice (*Oryza sativa*) cultures in Texas, Louisiana, and Florida. In southern Louisiana, where approximately 80% of rice is aerially seeded in water, Fulvous whistling-ducks are suspected of feeding extensively on planted rice and are considered a nuisance. To determine the extent of rice utilization by ducks nesting in southwestern Louisiana, we estimated food availability in ricefields and assessed feeding preferences. We also examined effects of sex and stage of reproduction on food selection. Feeding sites in Louisiana ricefields that were tilled and flooded in preparation for spring planting, contained abundant foods (mean $\pm$ SE = 109.0 $\pm$ 18.0 g/m^2), especially seeds of moist soil plants such as signalgrass (*Brachiaria extensa*), beakrush (*Rhynchospora* sp.), and flatsedge (*Cyperus iria*). Diets of males and females were similar ($P = 0.080$), but varied through the reproductive cycle ($P = 0.008$). Consumption of plant material was slightly reduced during the period of rapid ovarian follicle growth in females; however, ingestion of animal foods never exceeded 4%. Fulvous whistling-ducks exhibited feeding preferences ($P < 0.001$) with aquatic earthworms (Oligochaeta) and wild millet seeds (*Echinochloa* sp.) being preferred over other food taxa. Rice made up <4% of the diet and was selected in proportion to its availability before and during period of rapid follicle development. Almost 25% of the diet of incubating females consisted of rice; however, we concluded that crop depredation by Fulvous whistling-ducks (≤0.1%) was of minor importance relative to other potential sources of crop loss. Indeed, use of ricefields by whistling-ducks may actually benefit farmers if ingestion of seeds of undesirable plants reduces the need for costly herbicide treatments. *Received 18 April 1995, accepted 22 Sept. 1995.*

Private lands provide critical habitat for many wildlife species, but wildlife use of these areas sometimes results in significant economic losses (e.g., crop depredation) or conflicts with intended land uses (e.g., designation as critical habitat for threatened or endangered species). Since 1987, >1 million ha of rice (*Oryza sativa*) have been planted annually in the United States, mostly in the Mississippi Alluvial Valley, Gulf Coastal Plain, and Central Valley of California. In these regions, ricefields similar to other seasonally flooded habitats receive high use by shorebirds, wading birds, and waterfowl (hereafter waterbirds). Rice prairies in eastern Texas, for example, provide wintering habitat for >2 million waterfowl (Hobaugh et al. 1989). In Louisiana and California, harvested ricefields

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are used extensively by feeding and resting waterbirds in winter and during fall migration (Miller 1987, Heitmeyer et al. 1989, Rave and Cordes 1993). Indeed, flooding of ricefields after harvest to provide wintering and migrational habitat for waterbirds has been actively promoted by some farmers' groups, agricultural extension services, state and federal wildlife agencies, representatives of the rice industry, and private conservation organizations. Advantages to rice farmers participating in winter flooding programs include enhanced waterfowl hunting (leasing) and viewing opportunities, as well as potential for positive public image, retention of nutrients and topsoil, weed control, stubble removal, and lowered tillage costs.

Ricefields may also receive high use by spring-migrating and nesting waterbirds (Helm et al. 1987, Hohman et al. 1994), but avian use of fields after they have been prepared for planting until harvest is actively discouraged. Waterbird use of ricefields in spring and summer may be especially great in areas such as southern Louisiana where most rice is planted in water ("water seeding"); that is, pregerminated seed is aerially dispersed over fields following discing, flooding, leveling or dragging with a blade, and settling of particulate matter. Water-seeded fields generally are drained within 24 hours of planting, but are reflooded from 7–14 days after rice has sprouted until 2–3 weeks before harvest. Elsewhere rice is mostly broadcast or drilled in dry fields ("dry seeding"). Both dry- and water-seeded fields may be flooded in winter and are managed similarly after rice has sprouted, so the principal difference between planting methods is the presence of water in fields immediately before spring planting. In spite of increased risks of seed depredation by waterbirds, water seeding is preferred by Louisiana rice farmers to control weeds.

Fulvous whistling-ducks (*Dendrocygna bicolor,* hereafter whistling-ducks) occur worldwide in tropical and semitropical regions (Johnsgard 1978). Their expansion into the southeastern United States in the late 1800s coincided with the establishment of rice cultures in Texas, Louisiana, and Florida (Lynch 1943, Bolen and Rylander 1983, Turnbull et al. 1989). The first breeding records for whistling-ducks in Louisiana were obtained in 1939 (Lynch 1943). Their numbers in Louisiana increased rapidly in the 1940s to perhaps 10,000 ducks but soon decreased because of hazing practices adopted by rice farmers to reduce crop depredation (McCartney 1963). Introduction of aldrin (a pesticide used to protect seed against larvae of rice water weevil [*Lissorhoptrus oryzophilus*]) in 1960, further depressed whistling-duck populations in Texas and Louisiana. Although the Louisiana population has recovered somewhat since 1970 when use of aldrin-treated seed was discontinued, numbers of whistling-ducks remain below peak counts observed in the 1940s in spite of increased acreages of planted rice (Flickinger et al. 1977, Zwank et al. 1988).

Whistling-ducks nesting along the western Gulf Coastal Plain are migratory (Flickinger et al. 1973, Hohman and Richard 1994), arriving in southern Louisiana in February or March (McCartney 1963) when ricefields are being flooded in preparation for planting. Because of their presence in ricefields around the time of planting, occasionally in flocks of >2000 birds (Davis et al. 1944 in McCartney 1963), whistling-ducks are suspected of feeding on planted rice; consequently, they and, secondarily, other waterbirds (e.g., shorebirds and wading birds) are actively hazed from fields by rice farmers. We conducted this study to determine the extent of rice utilization by whistling-ducks nesting in southwestern Louisiana. Specifically, we estimated food availability in ricefields, assessed feeding preferences, and examined effects of sex and stage of reproduction on food selection by whistling-ducks.

METHODS

Whistling-ducks were collected on private agricultural lands in southwestern Louisiana, 9–15 May 1992 and 18 March–8 May 1993. Ducks were collected throughout the diurnal period and most were observed feeding for a minimum of 15 min before collection. Alcohol was injected into the gullets of specimens immediately after collection to minimize postmortem digestion of foods (Bailey and Titman 1984). We assigned pair status to birds on the basis of observations made before collection. Paired individuals were those showing active association, i.e., copulation, mutual display, female tolerance of the male or nonrandom spacing. Sex was assigned on the basis of cloacal characteristics (Hochbaum 1942). Specimens then were wrapped in paper towels and frozen in sealed plastic bags.

In the laboratory, thawed specimens were dissected and esophageal contents were removed, weighed (±0.01 g), and frozen. Carcasses were retained for contaminant analyses and proximate analyses of fat and protein composition. Ovaries removed from females were weighed (±0.01 g) and inspected for evidence of postovulatory follicles. We assigned females and their mates to the following reproductive categories, based in part on Krapu (1974): *Prenesting*—females with ovary mass ≤3 g and no post-ovulatory follicles; *Rapid follicle growth* (RFG)—preovulatory females with ovary mass >3 g and ovulating females; *Incubation*—birds collected at nest sites with embryo development ≥1 day (Weller 1956, Caldwell and Snart 1974).

Food availability was sampled at feeding sites by using a 6.1-cm diameter corer inserted to a substrate depth of at least 10 cm. Three or five core samples were taken at each feeding site. Corer contents (water column and substrate) were emptied into individual plastic bags and frozen. Thawed esophageal and core samples were hand-sorted to remove all macroscopic plant and animal material. Core samples were initially washed through a series of screens with 0.0625–4.0 mm^2 openings. Plant and animal taxa were separated, identified, and dried to constant mass (±0.001 g) at 50°C. Common names of invertebrates and plants followed Pennak (1989) and Scott and Wasser (1980), respectively. Food habits and availability were summarized on an aggregate percentage of dry mass basis (Swanson et al. 1974). Only food samples from birds containing ≥five items were included in the analysis (Reinecke and Owen 1980).

The proportion of plant material in the diet was compared by reproductive status and sex using two-way analysis of variance with Type III sum of squares on arsine square-root transformed data (PROC GLM, SAS Institute, Inc. 1987). To determine if whistling duck diets differed between day and night, we compared occurrences (presence or absence) of rice in incubating birds collected before and after 08:00 h with a Chi-squared test (Conover 1980). Incubators collected before 08:00 h and found to have food in their esophagi were assumed to have fed at night. Food preferences were assessed on a dry mass basis by using PREFER, a computer program that assesses preferences using nonparametric procedures (Johnson 1980). Only foods having an aggregate percentage of dry mass ≥1 and ≥50% frequency of occurrence in use or availability samples were included in the analysis. These included foxtail (*Alopecurus carolinianus*), rice, junglerice barnyardgrass (*Echinochloa colonum*), broadleaf signalgrass (*Brachiaria extensa*), rice flatsedge (*Cyperus iria*), other flatsedges (*Cyperus* spp.), spikerush (*Eleocharis* sp.), beakrush (*Rhynchospora* sp.), razorsedge (*Scleria* sp.), mudplantain (*Heteranthera limosa*), buttercup (*Ranunculus* spp.), lesser swinecress (*Coronopus didymus*), morningglory (*Ipomoea* sp.), and aquatic earthworms (Oligochaeta). Aggregate percentages of dry mass of taxa collected at feeding sites were assumed to represent food available to whistling ducks at those sites. Significance level was set a priori at $\alpha = 0.05$.

RESULTS

Food availability.—Forty-nine cores were taken at 13 feeding sites in five southwestern Louisiana ricefields. Estimates of food density in individual ricefields ranged from 53.1–171.5 g/m^2 and averaged (± SE) 109.0 ± 18.0 g/m^2. Plant material consisted almost exclusively of seeds and made up >98 aggregate percentage of dry mass of available foods (Table 1). A minimum of 28 plant taxa were identified in availability samples of which only four taxa contributed >5%. Although animal foods made up <2% of available foods, they were present at all feeding sites. Only one animal taxon (aquatic earthworms) contributed appreciably to available foods.

Food use.—Eighty-five of 121 whistling-ducks collected in this study had ≥5 food items in their esophagi. Four males collected without mates were of unknown reproductive status and excluded from subsequent analyses. The proportion of plant material in the diet of breeding whistling ducks was similar in males and females ($F_{[1,75]} = 3.15$; $P = 0.080$) throughout the reproductive cycle ($F_{[2,75]} = 1.31$, $P = 0.276$), but varied among reproductive categories ($F_{[2,75]} = 5.21$, $P = 0.008$). Plant food consumption was somewhat reduced during RFG relative to other reproductive categories, but never decreased below 96% even in females. We found no difference in the prevalence of rice in esophagi of incubating whistling-ducks collected before and after 08:00 h ($\chi^2 = 0.024$, 1 df, $P = 0.84$). Plant foods eaten by whistling-ducks consisted almost exclusively of seeds from ≥29 taxa, 14 of which contributed ≥1% dry mass or occurred with ≥50% frequency (Table 2). Aquatic earthworms were the only animal food contributing appreciably to the diet.

Feeding preferences.—Whistling-ducks exhibited feeding preferences

TABLE 1

FOOD AVAILABILITY AT FULVOUS WHISTLING DUCK FEEDING SITES IN FIVE SOUTHWESTERN LOUISIANA RICEFIELDS

Food taxa[a]	Aggregate % dry mass	Percent occurrence	Dry mass (g/m²) Mean ± SE	Range
Plant	98.2	100.0	106.8 ± 17.2	52.6–165.4
Seeds	96.0	100.0	101.4 ± 16.5	52.6–165.4
Alopecurus carolinianus	2.3	100.0	1.5 ± 1.0	0.0–5.6
Oryza sativa	4.2	60.0	4.1 ± 2.1	0.0–12.6
Echinochloa colonum	1.2	100.0	1.0 ± 0.4	0.2–2.1
Brachiaria extensa	30.6	100.0	34.4 ± 9.2	2.4–60.7
Cyperus iria	10.7	80.0	8.9 ± 4.6	0.0–23.7
Cyperus spp.	2.3	100.0	2.3 ± 0.8	0.3–4.5
Eleocharis sp.	3.9	80.0	3.1 ± 2.2	0.0–12.9
Rhynchospora sp.	19.0	100.0	29.5 ± 16.3	0.0–96.6
Heteranthera limosa	6.9	100.0	3.1 ± 2.6	0.0–14.5
Ranunculus spp.	4.1	100.0	3.6 ± 1.5	0.6–9.7
Coronopus didymus	1.2	80.0	0.9 ± 0.6	0.0–3.3
Ipomoea sp.	1.2	80.0	1.1 ± 0.5	0.0–3.2
Miscellaneous[b]	8.4	100.0	8.0 ± 2.5	1.0–17.0
Other[c]	2.1	40.0	5.3 ± 4.7	0.0–26.4
Animal	1.8	100.0	2.2 ± 0.9	0.5–6.1
Oligochaeta	1.0	80.0	1.3 ± 0.9	0.0–5.5
Miscellaneous[d]	0.9	100.0	0.8 ± 0.2	0.5–1.6

[a] Includes only taxa with aggregate percentage of dry mass ≥1 and frequency of occurrence ≥50%.

[b] Miscellaneous seeds were from *Mollugo verticillata, Cerastium viscosum, Commelina* sp., *Eclipta* spp., *Serinea oppositifolia, Scleria* sp., *Fimbristylis miliacea, Sisyrinchium* sp., *Digitaria sanguinalis, Lolium temulentum, Panicum* spp., *Phalaris* sp., *Polygonum hydropiperoides, Polygonum portoricense, Solanum americanum,* and *Verbena* sp.

[c] Other plant material included unidentified roots and tubers.

[d] Miscellaneous animals included unidentified vertebrate and invertebrate eggs, Copepoda, Coleoptera (larvae and adults), Chironomidae (larvae and pupae), Corixidae (adults), Formicidae (adults), and Gastropoda.

during both the prenesting ($F_{[13,22]} = 36.60$, $P < 0.001$) and RFG periods ($F_{[12,16]} = 10.68$, $P < 0.001$). Aquatic earthworms and junglerice barnyardgrass were preferred over other food items during both reproductive periods (Table 3). Spikerush, flatsedge, and beakrush seeds were underrepresented in the diets, whereas rice was eaten in proportion to its abundance (Table 3).

DISCUSSION

Food availability.—Density of potential foods, especially seeds of moist soil plants, was high in Louisiana ricefields used by feeding whistling-ducks in spring. Our estimate of seed density at whistling-duck feeding sites (101.2 ± 16.5 g/m²) was comparable to that (range, 90–134.4 g/m²) in impoundments in the Mississippi Alluvial Valley managed spe-

TABLE 2

FOODS OF MALE (M) AND FEMALE (F) FULVOUS WHISTLING DUCKS COLLECTED IN AGRICULTURAL AREAS IN SOUTHWESTERN LOUISIANA

	Aggregate % dry mass			
	<RFG[a]	RFG		
	M+F	M	F	M+F
Food taxa[b]	N = 35	N = 15	N = 16	N = 31
Plant	98.1	99.0	96.1	97.5
Seeds	97.6	98.9	96.0	97.4
Lolium temulentum	0.0	0.6	3.4	2.0
Triticum aestivum	0.0	0.0	0.0	0.0
Phalaris sp.	tr[c]	0.2	0.3	0.2
Oryza sativa	3.6	1.4	6.1	3.8
Echinochloa colonum	8.9	9.3	13.3	11.3
Brachiaria extensa	27.8	49.3	45.2	47.2
Panicum spp.	0.3	tr	tr	tr
Cyperus iria	30.3	0.2	1.7	1.0
Cyperus spp.	0.2	1.4	0.8	1.1
Eleocharis sp.	0.6	0.0	0.3	0.2
Rhynchospora sp.	12.1	32.4	21.6	26.8
Scleria sp.	3.0	3.4	0.8	2.1
Heteranthera limosa	8.6	tr	tr	tr
Ranunculus spp.	1.1	0.2	0.5	0.4
Miscellaneous[d]	0.5	0.5	2.0	1.3
Other[e]	1.1	0.1	0.1	0.1
Animal	1.9	1.0	3.9	2.5
Oligochaeta	1.7	0.6	2.6	1.6
Miscellaneous[f]	0.2	0.4	1.3	0.9

[a] Reproductive categories: <RFG = prenesting females (and their mates) with ovary mass ≤3 g and no postovulatory follicles; RFG = preovulatory females with ovary mass >3 g and ovulating females; >RFG = birds collected at nest sites with embryo development ≥1 day.

[b] Includes only taxa with aggregate percentage of dry mass ≥1 or frequency of occurrence ≥50%.

[c] Trace (tr), aggregate % dry mass <0.1.

[d] Miscellaneous seeds were from *Coronopus didymus, Commelina* sp., *Eclipta alba, Eclipta* sp., *Serinea oppositifolia, Ipomoea* sp., *Cyperus compressus, Fimbristylis miliacea, Sisyrinchium* sp., *Alopecurus carolinianus, Digitaria sanguinalis, Phalaris* sp., *Triticum aestivum, Polygonum hydropiperoides,* and *Verbena* sp.

[e] Other plant material included unidentified roots, tubers, and other parts.

[f] Miscellaneous animals included unidentified invertebrate eggs, Coleoptera (larvae and adults), Chironomidae (larvae and pupae), Tabanidae (larvae), Formicidae (adults), and Mollusca (Gastropoda and Pelecypoda).

cifically for production of moist soil plants (Reid et al. 1989) and 2–4 times greater than densities of seeds and all other plant foods in nearby coastal marshes (Jemison and Chabreck 1962, Hohman et al. 1990, Bielefeld and Afton 1992, Manley et al. 1992). Observed seed densities were substantially greater than previous estimates obtained in Louisiana ricefields in late winter (4.3–38.0 g/m^2; Harmon et al. 1960, Davis et al. 1961); however, if selection of feeding sites by whistling-ducks was in-

TABLE 2
EXTENDED

	% Occurrence				
>RFG	<RFG	RFG			>RFG
M+F	M+F	M	F	M+F	M+F
N = 15	N = 35	N = 15	N = 16	N = 31	N = 15
99.8	100.0	100.0	100.0	100.0	100.0
99.8	100.0	100.0	100.0	100.0	100.0
2.7	0.0	20.0	18.8	19.4	53.0
5.1	0.0	0.0	0.0	0.0	13.3
0.1	54.3	33.3	62.5	48.4	20.0
24.4	60.0	13.3	31.3	22.6	46.7
16.6	91.4	80.0	87.5	83.9	80.0
28.9	94.3	86.7	100.0	93.6	80.0
0.0	57.1	6.7	6.3	6.5	0.0
0.1	68.6	26.7	31.3	29.0	46.7
tr	45.7	46.7	18.8	32.3	13.3
tr	62.9	0.0	6.3	3.2	20.0
20.7	20.0	86.7	68.8	77.4	46.7
0.5	54.3	26.7	12.5	19.4	46.7
0.1	68.6	6.7	12.5	9.7	33.3
0.1	74.3	46.7	50.0	48.4	33.3
0.4	82.9	53.3	93.8	74.2	33.3
tr	28.6	26.7	18.8	22.6	6.7
0.2	68.6	60.0	100.0	80.7	26.7
0.1	51.4	46.7	68.8	58.1	13.3
0.1	40.0	60.0	93.8	77.4	26.7

fluenced by food availability (i.e., bird avoidance of sites with reduced food availability), then we likely overestimated food density in ricefields.

Abundance of potential foods in ricefields and their availability to feeding waterbirds vary temporally and geographically in relation to farming practices. Seed density in ricefield sediments is probably maximal immediately after autumn harvest (Harmon et al. 1960, Miller et al. 1989) and declines thereafter as a result of granivory, germination, physical degradation or destruction (e.g., tilling or burning), burial, and dispersal of seeds (McGinn and Glasgow 1963). To control noxious weeds such as red rice (*O. sativa* var.), most rice farmers in southern Louisiana practice a two-year planting cycle with rice cultivated in rotation with fallow, crayfish (Decapoda) aquaculture, pasture, or row crops (e.g., soybeans, milo, or wheat). Fields sampled in this study had been flooded and mechanically treated (disced and bladed) in preparation for water seeding of

TABLE 3

FEEDING PREFERENCES OF BREEDING FULVOUS WHISTLING DUCKS COLLECTED IN RICEFIELDS IN SOUTHWESTERN LOUISIANA

Reproductive status[a]	Preference rank[b]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Prenesting N = 35	OLI[c]	ECH	SCL	COR	RHI	ORY	ALO	RAN	HET	BRA	IPO	ELE	CSP	CIR
Rapid follicle growth N = 28	ECH	OLI	RHI	HET	ORY	ALO	CIR	BRA	CSP	ELE	COR	IPO	RAN	

[a] Reproductive status: Prenesting = females (and their mates) with ovary mass ≤3 g and no postovulatory follicles; Rapid follicle growth = preovulatory females with ovary mass >3 g and ovulating females.

[b] Rank 1 = most preferred.

[c] OLI = Oligochaeta, ECH = *Echinochloa colonum*, SCL = *Scleria* sp., COR = *Coronopus didymus*, RHI = *Rhynchospora* sp., ORY = *Oryza sativa*, ALO = *Alopecurus carolinianus*, RAN = *Ranunculus* spp., HET = *Heteranthera limosa*, BRA = *Brachiaria extensa*, IPO = *Ipomoea* sp., ELE = *Eleocharis* sp., CSP = *Cyperus* spp., CIR = *Cyperus iria*. Foods underscored with the same line have statistically similar rankings ($P > 0.05$).

rice (i.e., rice had not been planted in these fields in the preceding growing season). Seeds found in our samples presumably were produced during the previous growing season. Thus, it is apparent that the farming practices implemented between rice plantings may have a large influence on seed abundance in Louisiana ricefields in spring. Outside of the Gulf Coastal Plain, rice is mostly dry-seeded with or without crop rotation. Flooding of ricefields, as is practiced by farmers that water-seed rice, is necessary for waterbirds to gain access to potential foods. The effect on food availability of mechanical treatments performed in flooded ricefields is unclear, but the appearance of large numbers of birds (shorebirds as well as waterfowl) in fields following such treatments, especially blading (W. L. Hohman, pers. obs.), suggests that food availability may be enhanced.

Feeding preferences.—Greater than 96% of the diet of male and female whistling-ducks nesting in southwestern Louisiana was composed of plant material. Animal foods were actively selected by whistling ducks before and during RFG (i.e., period of high protein demand in females), and animal food consumption increased slightly (females only) during RFG. Nonetheless, the amount of animal food eaten by whistling ducks during RFG was less than that reported for any other small-bodied waterfowl species (Krapu and Reinecke 1992: tables 1–5). Other female ducks, even those that are primarily herbivorous (e.g., Gadwall [*Anas strepera*], Ankney and Alisauskas 1991), substantially increase their consumption of animal foods to offset high protein costs of reproduction (Krapu and Reinecke 1992), but that apparently is not necessary for female whistling ducks. Black-bellied whistling-Ducks (*Dendrocygna autumnalis*) also eat only small amounts (<10%) of animal foods during the nesting period (Bourne 1981). Although the amount of animal material at whistling-duck feeding sites was low relative to plant material, our estimate of animal food density (2.2 ± 0.9 g/m^2) was comparable to that (2.65–2.87 g/m^2) found in freshwater coastal marshes where spring-migrating blue-winged teal (*A. discors*) consumed $\geq$56% animal material (Manley et al. 1992). This result suggests that whistling-ducks fed inefficiently on animal foods or that not all foods found in core samples were available to birds. It further suggests that proteins required for production of eggs must come from exogenous or endogenous sources in addition to those contained in animal foods eaten by birds during the daytime.

Whereas previous studies reported that whistling ducks using ricefields eat mostly rice (Imler 1944 in Meanley and Meanley 1959; Bruzual and Bruzual 1983), we found only limited consumption of rice by ducks nesting in southwestern Louisiana. Rice made up <4% of the diet and was selected in proportion to its abundance before and during RFG. Almost

25% of the diet of incubating whistling-ducks consisted of rice, but we were unable to assess feeding preferences of incubating whistling ducks because feeding sites were unknown and food availability therefore could not be determined. Whistling-ducks are known to feed in flooded ricefields at night (Meanley and Meanley 1959). The potential for crop depredation presumably is greatest at night when whistling-ducks can feed undisturbed. It is possible that our sampling of birds only during the daytime underestimated rice utilization by whistling-ducks; however, prevalence of rice in esophagi of incubating birds collected before 08:00 h (assumed to have fed at night) was similar to that of incubators collected after 08:00 h. Sample size used for this comparison was limited, but we interpret this result as evidence that bias associated with time of collection was minimal. We therefore concur with Meanley and Meanley (1959) that, relative to other seeds, rice was of minor importance in overall diet of whistling-ducks nesting in southwestern Louisiana.

Our conclusion that whistling-ducks ate small amounts of rice relative to seeds of other plants should not be interpreted as evidence that they caused no damage in ricefields. Based on energy requirements calculated for nesting whistling-ducks, we estimate maximum daily consumption of rice to be 44.5 g/bird or 44.5 kg/day for the entire population in southern Louisiana (Table 4). Thus, we determined the potential for crop depredation in southern Louisiana during the 60-day planting period to be $\leq$0.1% of seeded rice (Table 4). Previous estimates of crop loss caused by feeding whistling-ducks ranged from 0.25–2.0% (Imler 1944 in Meanley and Meanley 1959; McCartney 1963, Bourne and Osbourne 1978), but estimates made before 1965 probably do not accurately represent losses under current farming practices. Use of pregerminated seed, for example, greatly reduces the duration of flooding after planting and thereby limits availability of rice to feeding ducks. (We observed no diurnal feeding by whistling-ducks in dewatered fields.) Removal of water within 48 hours of planting also minimizes puddling or trampling of seeded rice (i.e., reduced sprouting caused by birds stepping on and burying rice seed; McCartney 1963). Concentrated feeding by large flocks of whistling-ducks may result in localized crop losses greater than those projected in this study, but we believe that such instances are uncommon. Under current farming practices, depredation is restricted to fields planted early in the growing season (before 1 April) when whistling ducks occur in flocks and temperatures are cool, requiring farmers to hold water on seeded fields >48 h. We further suggest that crop losses caused by whistling-ducks are of minor importance relative to other potential sources of crop loss such as other seed predators, variable seed germination rates, weather, and disease. Indeed, we suggest that use of ricefields by whistling-ducks

TABLE 4
ENERGY REQUIREMENTS OF BREEDING FULVOUS WHISTLING DUCKS AND POTENTIAL CROP LOSSES IN SOUTHERN LOUISIANA RICEFIELDS

Calculation assumptions	Sources
Total seeded rice in southern Louisiana = 22,662,080 kg	
Rice acreage = 202,340 ha	Anonymous (1995)
80% of acreage was water-seeded (i.e., available)	R. Levy (pers. comm.)
Seeding rate = 140 kg/ha	Anonymous (1995)
Maximum daily rice consumption/bird = 45.9 g	
Whistling Duck Diet = 100% rice[a]	
True metabolizable energy of rice = 3.34 kcal/g	Reinecke et al. (1989)
Body mass = 756 ± 4 g	W. L. Hohman (unpubl. data)
Basal Metabolic Rate (BMR) = 75 * (body mass [kg])$^{0.72}$	Owen and Reinecke (1979)
= 61.3 kcal/day	
Daily energy expenditures = 2.5 BMR	Owen and Reinecke (1979)
= 153.3 kcal/day	
Maximum seasonal rice consumption/population = 27,539 kg	
Planting season = 60 days	Anonymous (1995)
Population = 10,000 ducks	Flickinger et al. (1977)

[a] Actual range = 3.6–24.3% (This study).

may actually benefit farmers if ingestion of seeds of undesirable plants reduces the need for costly herbicide treatments.

ACKNOWLEDGMENTS

We thank the county agents in Acadia (R. Levy), Evangeline (A. Mire), and Vermillion (C. McCrory [deceased], H. Cormier, and M. Shirley) Parishes, and also F. Bowers (U.S. Fish and Wildlife Service) and C. Cordes (Southern Science Center) for their support of this study. We are sincerely grateful to the many rice farmers and other cooperators who shared information with us and/or granted us permission to conduct this study on their land. R. E. Olson and G. A. Weisbrich assisted in the field or laboratory. Helpful reviews of our manuscript were provided by S. Linscombe, Z. A. Malaeb, S. W. Manley, K. J. Reinecke, B. A. Vairin, and M. W. Weller. Collections were authorized under scientific permits issued to the senior author by the U.S. Fish and Wildlife Service (PRT-747267) and Louisiana Dept. of Wildlife and Fisheries (LNHP-93-02 and LNHP-94-21). Before implementation of this study, procedures involving use and care of birds were reviewed and approved by the Animal Use and Care Committee, Southern Science Center.

LITERATURE CITED

ANONYMOUS. 1994. Rice industry guide. Rice J. 97:33–39.

———. 1995. Rice varieties and management tips. Louisiana State Univ. Agricultural Center Pub. 2270.

ANKNEY, C. D. AND R. T. ALISAUSKAS. 1991. Nutrient-reserve dynamics and diet of breeding female Gadwalls. Condor 93:799–810.

BAILEY, R. O. AND R. D. TITMAN. 1984. Habitat use and feeding ecology of postbreeding Redheads. J. Wildl. Manage. 48:1144–1155.

BIELEFELD, R. R. AND A. D. AFTON. 1992. Canvasback food density in the Mississippi River Delta, Louisiana: habitat and temporal differences. Proc. Annu. Conf. Southeast. Assoc. Game Fish Agencies 46:97–103.

BOLEN, E. G. AND M. K. RYLANDER. 1983. Whistling ducks: zoogeography, ecology, anatomy. Mus. Spec. Publ. 20, Texas Tech. Univ., Lubbock, Texas.

BOURNE, G. R. 1981. Food habits of Black-bellied Whistling Ducks occupying rice culture habitats. Wilson Bull. 93:551–554.

——— AND D. R. OSBORNE. 1978. Black-bellied whistling duck utilization of a rice culture habitat. Interciencia 3:152–159.

BRUZUAL, J. AND I. BRUZUAL. 1983. Feeding habits of whistling ducks in the Calabozo ricefields, Venezuela, during the non-reproductive period. Wildfowl 34:20–26.

CALDWELL, P. J. AND A. E. SNART. 1974. A photographic index for aging Mallard embryos. J. Wildl. Manage. 38:298–301.

CONOVER, W. J. 1980. Practical nonparametric statistics. John Wiley and Sons, New York, New York.

DAVIS, J. P., C. H. THOMAS, AND L. L. GLASGOW. 1961. Foods available to waterfowl in fallow rice fields of southwestern Louisiana, 1960–1961. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 15:60–66.

FLICKINGER, E. L., K. A. KING, AND O. HEYLAND. 1973. Pen-reared Fulvous Tree Ducks in movement studies of wild populations. J. Wildl. Manage. 37:171–175.

———, D. S. LOBPRIES, AND H. A. BATEMAN. 1977. Fulvous Whistling Duck populations in Texas and Louisiana. Wilson Bull. 89:329–331.

HARMON, B. G., C. H. THOMAS, AND L. GLASGOW. 1960. Waterfowl foods in Louisiana ricefields. Trans. N. Am. Wildl. Nat. Resour. Conf. 25:153–161.

HEITMEYER, M. E., D. P. CONNELLY, AND R. L. PEDERSON. 1989. The Central, Imperial, and Coachella Valleys of California. Pp. 475–506 *in* Habitat management for migrating and wintering waterfowl in North America (L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds.). Texas Tech Univ. Press, Lubbock, Texas.

HELM, R. N., D. N. PASHLEY, AND P. J. ZWANK. 1987. Notes on the nesting of the Common Moorhen and Purple Gallinule in southwestern Louisiana. J. Field Ornithol. 58:55–61.

HOBAUGH, W. C., C. D. STUTZENBAKER, AND E. L. FLICKINGER. 1989. The rice prairies. Pp. 367–383 *in* Habitat management for migrating and wintering waterfowl in North America (L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds.). Texas Tech Univ. Press, Lubbock, Texas.

HOCHBAUM, H. A. 1942. Sex and age determination of waterfowl by cloacal examination. Trans. N. Am. Wildl. Nat. Resour. Conf. 7:299–307.

HOHMAN, W. L., D. W. WOOLINGTON, AND J. H. DEVRIES. 1990. Food habits of wintering Canvasbacks in Louisiana. Can. J. Zool. 68:2605–2609.

———, J. L. MOORE, T. M. STARK, G. A. WEISBRICH, AND R. A. COON. 1994. Breeding waterbird use of Louisiana rice fields in relation to planting practices. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 48:31–37.

——— AND D. M. RICHARD. 1994. Remigial molt in Fulvous whistling ducks nesting in Louisiana. Southwest. Nat. 39:190–192.

JEMISON, E. S. AND R. H. CHABRECK. 1962. The availability of waterfowl foods in coastal marsh impoundments in Louisiana. Trans. N. Am. Wildl. Nat. Resour. Conf. 27:288–300.

JOHNSGARD, P. A. 1978. Waterfowl of the world. Univ. Nebraska Press, Lincoln, Nebraska.

JOHNSON, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65–71.

KRAPU, G. L. 1974. Feeding ecology of Pintail hens during reproduction. Auk 91:278–290.

——— AND K. J. REINECKE. 1992. Foraging ecology and nutrition. Pp. 1–29 *in* Ecology and management of breeding waterfowl (B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu, eds.). Univ. Minnesota Press, Minneapolis, Minnesota.

LYNCH, J. J. 1943. Fulvous tree-duck in Louisiana. Auk 60:100–102.

MANLEY, S. W., W. L. HOHMAN, J. L. MOORE, AND D. RICHARD. 1992. Food preferences in migrating Blue-winged Teal in southwestern Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game Fish Agencies. 46:46–56.

MCCARTNEY, R. B. 1963. The Fulvous Tree Duck in Louisiana. M.S. thesis, Louisiana State Univ., Baton Rouge, Louisiana.

MCGINN, L. R. AND L. L. GLASGOW. 1963. Loss of waterfowl foods in ricefields in southwest Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 17:69–79.

MEANLEY, B. AND A. G. MEANLEY. 1959. Observations on the Fulvous Tree Duck in Louisiana. Wilson Bull. 71:33–45.

MILLER, M. R. 1987. Fall and winter foods of Northern Pintails in the Sacramento Valley, California. J. Wildl. Manage. 51:405–414.

———, D. E. SHARP, D. S. GILMER, AND W. R. MULVANEY. 1989. Rice available to waterfowl in harvested fields in the Sacramento Valley, California. Calif. Fish Game 75: 113–123.

OWEN, R. B., JR. AND K. J. REINECKE. 1979. Bioenergetics of breeding dabbling ducks. Pp. 71–93 *in* Waterfowl and wetlands—an integrated review (T. A. Bookhut, ed.). LaCrosse Printing Co., Inc., LaCrosse, Wisconsin.

PENNAK, R. W. 1989. Fresh-water invertebrates of the United States. John Wiley & Sons, New York, New York.

RAVE, D. P. AND C. L. CORDES. 1993. Time-activity budgets of Northern Pintails using nonhunted rice fields in southwest Louisiana. J. Field Ornithol. 64:211–218.

REID, F. A., J. R. KELLEY, JR., T. S. TAYLOR, AND L. H. FREDRICKSON. 1989. Upper Mississippi Valley wetlands—refuges and moist-soil impoundments. Pp. 181–202 *in* Habitat management for migrating and wintering waterfowl in North America (L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds.). Texas Tech Univ. Press, Lubbock, Texas.

REINECKE, K. J. AND R. B. OWEN, JR. 1980. Food use and nutrition of Black Ducks nesting in Maine. J. Wildl. Manage. 44:549–558.

———, R. M. KAMINSKI, D. J. MOORHEAD, J. D. HODGES, AND J. R. NASSAR. 1989. Mississippi Alluvial Valley. Pp. 203–247 *in* Habitat management for migrating and wintering waterfowl in North America (L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds.). Texas Tech Univ. Press, Lubbock, Texas.

SAS INSTITUTE, INC. 1987. SAS/STAT guide for personal computers, Version 6 ed. SAS Inst., Inc., Cary, North Carolina.

SCOTT, T. G. AND C. H. WASSER. 1980. Checklist of North American plants for wildlife biologists. The Wildlife Society, Washington, D.C.

SWANSON, G. W., G. L. KRAPU, J. D. BARTONEK, J. R. SERIE, AND D. H. JOHNSON. 1974. Advantages in mathematically weighing waterfowl food habits data. J. Wildl. Manage. 32:302–307.

TURNBULL, R. E., F. A. JOHNSON, AND D. H. BRAKHAGE. 1989. Status, distribution, and foods of Fulvous whistling ducks in south Florida. J. Wildl. Manage. 53:1053–1057.

WELLER, M. W. 1956. A simple field candler for waterfowl eggs. J. Wildl. Manage. 20: 111–113.

ZWANK, P. J., P. M. MCKENZIE, AND E. B. MOSER. 1988. Fulvous whistling-duck abundance and habitat use in southwestern Louisiana. Wilson Bull. 100:488–494.